JETER

Modern Illuminants and Comparative Cost of Lighting

Electrical Engineering

B. S.

1910

UNIV OF
ILLINOIS
LIBRARY

UNIVERSITY OF ILLINOIS
LIBRARY

Class 1910 Book J51 Volume

MODERN ILLUMINANTS AND COMPARATIVE COST OF LIGHTING

870
18
M/D

BY

GEORGE GUY JETER

THESIS

FOR

DEGREE OF BACHELOR OF SCIENCE

IN

ELECTRICAL ENGINEERING

COLLEGE OF ENGINEERING

UNIVERSITY OF ILLINOIS

PRESENTED JUNE 1910

1910
J51

UNIVERSITY OF ILLINOIS

June 1 1910

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

GEORGE GUY JETER

ENTITLED MODERN ILLUMINANTS AND COMPARATIVE COST OF LIGHTING

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science in Electrical Engineering

H. T. Plaha
Instructor in Charge

APPROVED: Ernst Berg

HEAD OF DEPARTMENT OF ELECTRICAL ENGINEERING

197653

Digitized by the Internet Archive
in 2013

http://archive.org/details/modernilluminant00jete

1910
J51

TABLE OF CONTENTS.

	Page
Introduction	1.
Electric Lighting	3.
Tungsten, Carbon, Nernst.	
Gas Lighting	9.
Coal Gas	9.
Acetylene	11.
Gasoline Lighting	15.
Petroleum	17.
Summary	18.

UIUC

MODERN ILLUMINANTS

AND THE COMPARATIVE

COSTS OF LIGHTING

INTRODUCTION

The need of light by all makes the comparative cost of lighting of interest to everyone. In the past a great many tests and comparisons of various lights have been made and the results and conclusions published. But in most cases, the tests and comparisons have been for two or three of the modern methods and have often been of an advertizing nature. With all of these tests very little has been done towards a general comparison of all lights.

It is therefore the object of this paper to gather together and place in concrete form all obtainable data relative to modern illuminants and the cost of producing light from them. Data as to cost of production will be given from some authority wherever possible, the writer supplying only such data as is not readily obtainable. Arc lighting will not be taken up as its field is becoming more for outdoor work and advertizing purposes, and this comparison is more for

indoor illumination.

Electricity, gas, acetylene, gasoline and petroleum will be considered. Under electric lighting, the tungsten, 3.1 watt and 3.5 watt carbon, and the nernst lamps will be taken up, for gas lighting, the inverted and upright mantle and the old open flame lamp s will be discussed. For acetylene lighting the .5 foot open flame burner, which is used mostly in residence work, and for gasoline lighting, the two systems, the hollow wire and stove generating systems will be treated. For petroleum lamps, the ordinary wick lamp and the recent mantle burners will be considered. Some other forms of lamps, as the alcohol mantle lamp and other forms may at times be mentioned.

In comparing the cost of illuminants, a strictly dollars and cents comparison is not sufficient, and would not be fair to all forms of lamps. Some lamps while cheaper in actual cost of production, are much more expensive, all other things considered. In order to make an impartial comparison of all light sources, they should be compared in somewhat the following manner.

I. First cost.

II. Cost of operation.

III. Convenience and ease of manipulation.

1. Dirt, smoke and soot, and the effect upon decorations.

2. Heat given out.

3. Hygenic qualities. Odors given off.

4. Lighting and extinguishing.

5. Labor and trouble to keep in operation.

6. Color and quality of light.

IV. Reliability and service.

1. Chances for break-downs.

2. Time and trouble to repair.

V. Danger and risk.

1. Life risk.

2. Fire risk.

Each of the various systems will be discussed separately according to the above form and a general summary given in which all will be compared and tables of relative costs of operation, relative hazards, and color values will be given. Comparisons of costs will be made for both the mean spherical C. power and the mean lower hemispherical CP. In making a comparison of costs in terms of mean spherical candle-power, it is assumed that the greater part of the light in the upper hemisphere can be directed by efficient reflectors into the lower hemisphere or useful zone. As this is sometimes questionable and the fact that a lamp giving the greater part of its light in the lower hemisphere is in some ways superior, it is thought best to use the mean lower hemispherical candle-power as a basis as well.

ELECTRIC LAMPS

The tungsten lamp is the latest developed high efficiency incandescent lamp. The filament consists of a wire of metallic tungsten and is manufactured in several ways. Due to the lower resistance of an equal length of tungsten filament than of carbon, it is necessary for the same voltage to have a filament of greater length and as fine as can be made, at the same time being strong enough to withstand jars and shocks. Tungsten lamps are now made to be burned in any position, yet it is best to burn them in as nearly vertical position as possible. Some forms of lamps make use of an additional support, others a spring support at one end, to take up the sag incident to the filament heating and expanding. However, tests have

shown that the latter arrangement does not decrease liability to breakage but rather increases it.

The first cost of an electric system is variable depending largely upon local conditions as far as the cost of wiring is concerned. However, wiring in most cases will be practically the same as the cost of piping for gas or acetylene, and the entire cost of wiring and fixture s will be less by far than the cost of most gasoline plants. The cost of fixtures can hardly be estimated due to the great variety of fixtures and their cost, some selecting one kind and some another. It is thot safe to assume that the average cost of wiring and fixtures will be about $ 4.50 per lamp, excluding lamps. A slight additional cost must be added for switches. It is believed that the above price will hold equally as well for "knob and tube" or conduit work, since the price of the former in small towns will be near $ 1.50 per opening, while conduit work can often be had for less than $ 2.00 per opening.

The price of tungsten lamps has been reduced and much has been done towards their stability. Even cheaper and better lamps may be expected in the future due to the discovery of "ductile" tungsten. The following prices, quoted from the Electrical World, are made by the Commonwealth Edison Company of Chicago, for tungsten lamps when (standard) carbon lamps are given by consumers in exchange.

Size.			Cost with carbon lamp.	Cost plus $o.25
25 watt	clear		$ 0.45	$ 0.70
40 "	"	small	.50	.75
40 "	"	large	.55	.80
60 "	"		.60	.85
100 "	"		1.10	1.35
40 "	"	Meridian	.65	.90
60 "	"	"	.85	1.10

Additional cost for frosting $ 0.05 per lamp.

There is no doubt a large margin in counting the cost of carbon lamps at $ .25, since often standard lamps may be bought as low as $ .16. Then, too, the value of the lamps must be considerably less since they have been burned.

The rating of tungsten lamps is 1.25 watts per CP. and will not be far from this in most all cases. The life of a tungsten lamp is taken as 1000 hours, life in all cases being considered at an end when the CP. of the lamp falls below 80% of its rated value. The lamps burn equally as well on A.C as on D.C but show a slightly longer life on D.C.

With the electric light there is no dirt made, no soot or smoke to damage decorations. That this is no small matter is shown by the fact that in some cities, real-estate dealers in rental contracts specify that electric lights shall be the only form of illumination used. The heat given off by an incandescent lamp is very small and a cool room is a possibility. Since there is nothing burned, there is no odor given off and no additional ventilation is required. One of the best qualities of the electric system is the remote control which may be installed, its simplicity and ease of manipulation. A light may be had at any time and may be carried about the room with no danger of upsetting and a minimum of life and fire risk. The labor of keeping an electric system in operating order consists of a monthly cleaning of globes and reflectors and perhaps a yearly cleaning of fixtures. In the case of a burned out globe, a few seconds to screw in another, which can be done by the most inexperienced without danger, is all that is necessary. The color of light from a tungsten lamp is nearly white and therefore colors will appear in the correct relation. Another commendable feature of the tungsten

lamp is that with a variation of voltage the color of light changes only in such a small amount that there is little or no flicker. This is a good asset in towns where the capacity of the plant is small and where any sudden demand for current means a drop in voltage.

The chances for interruption of service with the electric system depends, first upon the location, that is the reliability of service afforded by the local lighting company. This depends to a great extent upon the size of the town. One could hardly expect as good service in a small town as can be afforded in a city. In a properly installed system, the liability to trouble from wiring is very small, the blowing of a fuse is not frequent, and a new fuse plug can be replaced as easily as a burned-out lamp. Breakage of lamps in service does not often occur and in case it does, with the tungsten lamp, the damage can generally be repaired and the lamp will burn for perhaps 200 to 300 hours longer, with an increased efficiency. Lamps repaired in tests made at the University Experiment Station often burned as long as 300 to 400 hours after repairing.

The carbon filament lamp has a very low first cost, standard lamps can be had at 16 to 25 cents. The efficiency is not so high as that of the tungsten lamp. Two ratings are given, one 3.1 watts and the other 3.5 watts. The 3.1 watt carbon is in reality a 3.5 watt lamp burned at a higher voltage, giving a higher efficiency but having a shorter life. The cost of the lamp and the loss of shorter life is thus balanced against the saving in current. This lamp has another advantage over the tungsten in that the filament is not so easily broken by shocks and jars, and due to its low first cost it can be used in places where the liability of breakage is great. The color of light from a 3.1 watt lamp is better, more nearly white. The light from a carbon filament lamp is rich in orange and red rays. It

takes four times the intensity of red light to give the same reading power as of white light. A variation in voltage on a carbon lamp causes a marked change in C.P. and color of light, the lamp blinks. In a test at the University Experiment Station, a 5 % increase in voltage caused an increase in candle power of 33.2 %, while a 5 % decrease caused a drop of 31 %

The means of a more efficient way for producing light from electricity, than is afforded by the carbon lamp, led Dr. Nernst to make investigations which resulted in the production of the Nernst lamp. The filaments or glowers are made of oxide of yttrium and zirconium, rare earths, and can be burned in open air. The filament burns with a brilliant white light rivaling the tungsten lamp in color. The glowers at ordinary temperatures are non-conductors, they have to be heated up to a point at which they will become conductors. Heater coils of platinum wire are used to accomplish this and are automatically switched on and off. Due to the marked negative temperature coefficient of the glower it is necessary to put in series with these a balast of iron wire, which is placed in avacuum tube to prevent oxidizing. Since all these auxiliaries are needed with the lamp a special fixture or case is required. The heating of the filaments requires some little time, 35 seconds, and hence the lamps are not instantaneous lighting, which is an objection, especially in stores should a light be needed at the time of waiting on customers.

For comparison with other forms of lamps the three glower Nernst lamp has been selected. The rating and life of the various parts of the recent improved Nernst lamp has taken from the Electrical World, are as follows.-

Glowers.	Watts per unit.	Voltages.	Watts per mean lower hem. CP.	Watts per mean spherical CP.
1	66	110	1.38	2.5 #
1	88	220	1.20	2.16
1	110	110-220	1.20	2.16
1	132	110-220	1.20	2.16
2	264	220	1.20	2.16
3	396	220	1.15	2.07
4	528	220	1.09	1.96

These figuers are form tests in the Nernst laboratory using clear glass globes.

Note.- Data computed as follows;- divide M.L. H'C'P' by 2 and add 10 % to obtain M.S.C.P.

LIFE TESTS OF VARIOUS PARTS.

Part	cost.	Hours of life. D.C 110 V to 220 V. 110 --- 220		Alternating current. 25 Cycles. 110V	220V.	60 Cycles. 110V	220V.	133 Cycles. 110V.	220V.
Glower	$ 0.25		600		400		800		800
Heater	.75		3000		3000	3000	3000	3000	3000
Ballast	.25	15000	15000	15000	15000	15000	15000	15000	15000
Screw burner	.75	600	600	600	600	600	600	600	600

Case, & - three glower lamp complete - $ 6.00

The first cost of the unit will be in addition to the cost of wiring, however fixtures need not be used. Attention should also be called to the factthat due to the higher efficiency fewer units are required and 220 volts may be used, thus lessening the cost of wiring. Advantage may be had of the electric remote control and

practically all the other conveniences of the electric system may be had. Due to the greater number of parts and the slightly more complex mechanism of this lamp, it will be more likely to get out of order and more difficult for the unskilled to repair. All the parts are made in duplicate and their replacement may be quickly mastered. During eight years of service at the university these lamps have given perfect satisfaction.

GAS LIGHTING.

COAL GAS.-The invention of gas lighting by means of coal gas came in 1792, when an Englishman, William Murdock, obtained gas from soft coal in sufficient quantities to light his shop in Cornwall England. Previous attempts were made but were either impractical or failed. Soon afterwards came the discovery of oil gas and the carburetting of water gas.

The gas lighting industry met with a great deal of opposition at first but this gradually subsided and the industry grew rapidly. At first the open flame burner was used. The poor efficiency of this burner and poor generating apparatus made gas lighting very expensive. The advent of the gas mantle produced by Dr. Aner von Welsback, together with improvements in generation, have brought gas lighting to the front as one of the most efficient of modern illuminating factors. Gas lighting has some inherent qualities which are drawbacks and altho a great deal has been done towards overcoming these there is much room for improvement.

The first cost of a gas lighting system lies in the cost of the piping and fixtures, varying naturally with the locality and the kind of fixtures selected. This cost will usually be about the same

as the cost of wiring, a standard price for out-let being $ 2.00 in smaller cities. Fixture costs are about the same as in electric lighting, being if anything a little cheaper for gas.

Gas light is produced by the combustion of gas or its union with the oxygen of the air, thus requiring an air supply and giving off the production of combustion, carbon dioxide and water vapor, also soot and dirt and heat in rather large quantities, enough in warm weather to heat a room. Without doubt the dirt and soot from the lamps damage the decorations which is of importance as mentioned in the case of electric lighting. Odors given off due to improper regulation of burners and to leaks in the piping are objectionable, especially in the winter months. To insure complete combustion, an equal regulation for a heated or a cold burner, the thermostat of recent invention has been brought out. It is claimed that this will give equal regulation at all times and with varying quality, and pressure of gas. The hygenic value of gas lighting is to be doubted, it being claimed that at the high temperatures of the Bunsen burner all odors and impurities in the air are consumed. Tests have been made to show that with the increased amount of carbondioxid in the air, there is no bad effect upon the human body and that it is the increased quantity of water vapor in the air. These tests were of short duration and were made with human subjects., but even from these it would be hard to prophesy the results of a prolonged test. One of the chief draw backs to gas lighting is the lighting and extinguishing. The need of a good system of remote control is felt by the industry, and various spark gap and magnetic valve systems are on the market, but most of these are rather expensive and complicated. The use of a gas lighting system on a combination gas and electric fixture is prohibited by the underwriters. Pilot light or sub-flames are also

used, requiring of course special apparatus and consuming gas. The gas consumed is no small item, when the lights are used only occasionally, also draughts will blow them out and the gas will escape into the room, to say nothing of the trouble to keep lighted. If none of the above systems are used, it means that matches will be used, with their liability of coming into the hands of children, adding greatly to the hazard.

The up-keep of a gas lighting system requires the usual attention to fixtures, but increased care must be used else the mantles will be broken. In some cases piping may have to be cleaned out. The color of light given out by a gas mantle is greenish white, that for the open flame is pale orange to yellowish white,

The interruptions in service may be due to conditions at the plant, water in the mains, or breakage of mantles. Breaking a mantle greatly decreases the candle power and efficiency. A hole in the mantle means a greater price for illumination. Putting on a new mantle means letting the lamp cool down and then requires some little skill.

The risk in gas lighting lies in the danger from asphixiation, explosions, and risk from the use of matches. A gas leak will often occur beneath floors or in side walls and enough gas escapes to make an explosive mixture before it is discovered. The accidental lighting of a match or even looking for leaks with a match will then set off the mixture.

ACETYLENE- In 1862, Woehler announced the successful manufacture of acetylene gas from calcium carbide, thus perfecting the experiments of others. The high price of carbide at that time made the use of acetylene for illuminating impractical. In 1892, Thomas L. Wilson an electrical engineer of Spray N.C. accidentally discovered the

manufacture of calcium carbide by using the electric furnace. This discovery put acetylene lighting on a practical basis and since that time its use has spread until now it is world-wide.

Acetylene is a rich hydro carbon gas which is given off when water and calcium-carbide come in contact. There are two methods available for the manufacture of this gas, water-to-carbide generators, and carbide-to-water machines. In the first water is sprayed upon the carbide. The spray is automatically regulated by the rising of the gas bell used to store the gas. In the other form the lumps of carbide are dropped into the water. Two methods of feed are in use, the gravity and the forced which consists of pushing the carbide off of a shelf by means of a sort of clock works. The water-to-carbide generator has the advantage that most any form or size of carbide can be used, while the other method requires a given size of lump carbide. The carbide-to-water method has the advantage of cool generation due to the large amount of water present. When carbide comes in contact with water the action as far as heat is concerned is analogous to the slacking of lime. For obtaining pure gas, cool generation is necessary and the washing of the gas as it bubbles up thru the lime water in the carbide-to-water machine is one of its great advantages. An advantage to the carbide-to-water machine is that the recharging is much easier than in the other form.

The first cost of the generator for an acetylene plant of the smallest size, 25 pounds of carbide capacity, is $ 120.00 Piping and fixtires are about the same as for gas, with the possible advantage that the size of pipe may be smaller. Two sizes of burners are used, the .5 and the 1.0 foot burner. There are now mantles on the market for acetylene but they are not sufficiently perfected for practical use.

Acetylene, in burning, like other forms of gas lighting robs the air of oxygen and gives out the usual products of combustion, carbon dioxid and water vapor, also traces of other substances like sulphur dioxid, which will unite with the water vapor of the air, forming sulphuric acid, doing damage to book bindings and decorations. As for carbondioxid, this gas is not nearly the offender that coal gas is, since less gas is burned for equal amounts of light. Acetylene requires 2 1/2 cubic feet of oxygen per cubic foot of gas against 10 feet of oxygen per foot of coal gas. Acetylene gives off 2 feet of carbondioxid per foot of gas consumed against 7 1/2 feet for coal gas. The rating of acetylene as agas is 240 candles and the rating of coal gas in the city of Philadelphia is 19 to 20 candles. There is produced by acetylene in burning some soot and dirt. Less heat is given off since less gas is burned, the inverted gas lamp consumes 3 cubic feet of gas per hour against one foot of acetylene for the same illuminating power.

In the matter of lighting and extinguishing we meet with the same problem as in gas lighting and with the same appliances to overcome this difficulty. To keep an acetylene plant in working order requires recharging the generator three of four times a year. This is rather dirty work and requires some time, and is attended with danger. In case the gas generated is not pure the pipes and burners will become clogged.

The color of acetylene light is nearly white, plants may be grown by the aid of it. The analysis made by physicists shows the proportions of light to be.-

Color.	Sun-light.	Acetylene.
Red	1	1.03
Yellow	1	1.02
Green	1	0.71

Color.	Sun light.	Acetylene.
Blue	1	1.46
Violet	1	1.07

Ultra violet rays in acetylene are practically absent. We note from the above that the light is particularly strong in the blues and violets.

The kind of service in any case depends upon the type of generator, its ability to supply the demand for gas at any time, and and to do so with cool generation, that the gas may be pure and not clog the pipes at some future time.

The danger from suffocation is not great in the case of acetylene since the burners are small and the amountsof poisonous gases present are small. Carbon monoxide is present in only .01 percent. The gas is irritating rather than somnific in effect, and the peculiar odor, while capable of being removed is left in the gas as a warning.

Acetylene may explode in two ways.

1. Admixture of air requiring further ignition.

2. Compressed acetylene which may be set off by jars or shocks.

Due to the second case the use of liquid acetylene is prohibited and generators are fitted with release valves.

Very strict rules are necessary in the use of acetylene and the transportation and storage of carbide. In recharging no form of flame can be used near the generator, and special cut off valves are used to cut off the gas supply in the gas bell and house piping. Carbide must be stored in sealed steel drums, to be air and water tight and of stated strength. Generators should be located in places where children and meddlers cannot bother them and carbide is not to be stored in insured buildings.

GASOLINE LIGHTING.

Gasoline lighting is of rather recent development. Two systems, both using mantles, will be taken up. These are,- the hollow wire system in which the gasoline is stored in a tank and is forced thru the hollow wire to the various lamps, each lamp being its own generator; the other system is the stove generating system, the gasoline passing thru a generator where the gas is made by vaporizing the liquid and is then carried to the lamp thru a tin pipe varying in diameter from one to three inches. There are instantaneous lighting units on the market to be used on the hollow wire system. These lamps are generated all the time by allowing them to burn on a subflame of sufficient size to keep them hot.

The first cost of a five lamp plant, either system, will be in the neighborhood of $ 100.00, however some forms of hollow wire plants which require generating at the lamp each time may be had as low as $ 60.00. Gasoline attacks any met als and eats out the rubber washers or tubing in contact with it. In the best plants all parts in contact with gasoline are made of brass or copper. Due to this corrosive effect of the gasoline results the short life of some of the parts. In order to obtain the best results from a gasoline plant it is necessary to use high test (87) gasoline, at a considerable increase of cost. The cost is usually prohibitive and the product is hard to obtain. The result is that most plants use cheap gasoline which will clog up the machine and cause them to run at poor efficiency. The forms of gasoline used are not sold for illuminating purposes, this being shown by the frequent lables of the Standard Oil Company, the largest producers of gasoline in the world, "Gasoline

not sold for illuminating purposes". The use of this cheap gasoline requires that the machine be cleaned two or three times a year.

There is a considerable amount of heat, soot, and odor given off by a gasoline lighting plant, to say nothing of the odors given off by the gasoline itself, which are frequently objectionable in groceries and meat markets. Lighting a gasoline lamp means generating it, if of the hollow wire kind, climbing up to the lamp in a crowded store over goods and generating with a swab, with the liability of dripping. With instantaneous lighting systems generating is needed only at the tank but here we have a light ready for any leaking gasoline or gas. One pint of gasoline when evaporated is capable of exploding 200 cubic feet of air. With the hollow wire system we have the gasolinepiped right thru the building and any leak in the wire or fittings means the escape of gasoline. In case of fire it means the spraying of gasoline on the fire. In case of the stove system the danger from leaks is hardly as bad, as only the vapor which is generally well saturated , escapes. There is a great risk in the storage tank in case of fire; only one system on the market is fitted with a release valve and pipe to the open air.

The light given out is very similar to that of the mantle gas lamp.

A great amount of care is necessary with the system. Filling the tank is attended with danger; pumping up, generating, and lighting the lamps, making repairs as putting on new washers and mantles, are some of the duties necessary to operation. Too much gas pressure means blowing off gas mantles, or breaking them, and even if this is not the case there is considerable noise.

PETROLEUM LIGHTING.

The oil lamp burning a wick has been in use for many years. This lamp was one of the first forms perfected and little change has been made in it. The mantle oil lamp, of recent invention, is the ordinary lamp having a circular wick over which is suspended a "rag" mantle, having large meshes. This mantle is very durable and is suspended in the chimney so that mantle and chimney may be removed together for lighting the wick. The wick is about 1/8 inch in thickness and 7/8 inch mean diameter. The mantle is about three inches high. The wick is lighted and the mantle heat s up, burning with a brilliant greenish white light. This lamp has a considerable increase in efficiency over the ordinary lamp. It requires frequent and fine adjustment to keep the lamp up to full candle power, and to be kept from smoking. With the lamp tested considerable trouble was had from smoking. Soot would collect on the mantle which required turning down the lamp till the soot was burned off.

The wick lamp gives a yellowish white light. Both lamps burn ordinary petroleum or coal oil.

The first cost of a wick lamp depends of course on the kind of lamp, and may be less than one dollar or may cost several. The cost of a mantle burner, complete with mantle, fitting any wick lamp is $ 3.00.

There are many objections to oil lighting, due to the inherent characteristics of the method. The combustion requires oxygen from the air and gives off carbon dioxid and water vapor and other gases and at times odors, soot and smoke. While they can be seen only when the lamp is smoking, they are constantly given off as is

evidenced by the coating of soot on the wall paper, especially over the lamp. The oil is another source of dirt. Oil will get thru the best of burners and run down on the outside of the lamp, acting as a dust catcher or getting on the hands, then on the clothing or anything else touched. Besides the dirt there is a considerable quantity of heat given off.

To operate an oil lamp requires frequent adjustment to keep it up to candle power due to the oil lowering in the bulb. Draughts will cause them to smoke and the soot collecting on the sides of the chimney will cut down the light and therefore the efficiency. In order to keep the chimney clean it must be cleaned often, sometimes daily, and this with the filling and triming takes considerable time and is by no means a desirable piece of work. To light the lamp requires matches which add to the hazard. Upsetting lamps, setting them too near curtains or other inflamable materials and occasional exploding of a lamp increases the danger to life and of fire. Storage of oil about buildings is undesirable, also it may be used for kindling fires, which is a dangerous and wasteful practice.

SUMMARY.

From the view point of hygenic qualities, the electric system stands first. There is neither dirt nor gas given off. Acetylene is second, with gas a close third, then come oil and gasoline. As a matter of lighting and the trouble of operating, electity again stands first, with gas second, acetylene third, and gasoline and oil next. For the trouble of lighting and extinguishing, electricity is first, with gas and acetylene, instantaneous lighting gasoline, oil and gasoline(generating) systems, following in the

order named. For reliability electricity should be given perhaps first place, with gas second, then acetylene and gasoline and oil.

With mantle lamps there are many chances from breakage, some of which are not often considered, but which in many cases are responsible. With the gas fixture there can be no shock absorbers and the mantle must take all jars. In inverted lamps, especially gasoline, there is great liability to breaking the mantles in lighting. Mantles are susceptable to breaking from a fly lighting on them, which breaks a small hole. Considerable trouble has been experienced in some places from this.

The life risk varies with different consumers. Few persons other than electrical workers are now injured with electricity. Carelessness is responsible for most accidents, but with electricity the injury sustained is by only one person, while an explosion or suffocating may result in the death of many. The list of fires from illuminants as compiled by the underwriters for the year 1908 is as follows.

Fires.	Percent of total.	Causes.	Estimated Damage.	Percent of total.
1046	9.63	Electric light	$ 16,294,540.	64.2
8222	76.25	Kerosene & gasoline	8,441,445.	33.2
1033	9.6	City (coal) gas.	368,970.	1.46
453	4.11	Candles.	282,080.	1.12
4	.037	Acetylene.	13,260.	.057
22	.204	Rays of sun.	12,965.	.053
	100.			100.

Some coment is needed in the case of electric light, as "electric wiring" is a common cry when no other reason is known. If figures were available showing the percentage of loss in each case to the total value of buildings having a given system installed, a dif-

ferent story would be told. Gasoline and perhaps in some cities acetylene systems are not permitted inside the fire-districts. That gasoline lighting is not looked upon with favor by the insurance companies, is shown in a statement of Mr. C. F. Persch, Underwriter's rate inspector for Illinois, in which he brands gasoline lighting as 'a menace to property and public safety.'

The color of light given by the various lamps, from Barrows is as follows.

Kind of lamp.	Color of light.
Tungsten.	Very nearly white.
Carbon (3.1 to 3.5 watts)	Yellowish white to orange.
Nernst	Very nearly white.
Gas mantles	Greenish white.
Open gas.	Pale orange to yellowish white.
Acetylene.	Nearly white.
Gasoline mantle.	Greenish white.
Oil mantles	Very greenish white.
Oil (wick)	Orange, slightly yellow.
Candle.	Orange yellow.
Sun (high in sky)	White.

The color of incandescent electric lamps, varies with the voltage, becoming nearer white as the voltage increases.

COST OF OPERATION. JETER.

KIND OF LAMP.	Consum. Per Hour	Cost of Illuminant.	Cost of Operation	Cost of Renewals per Hour	Total Cost. Lamp Hr.	M.S.C.P. of Unit	Cost Per M.S. C.P. Hr	Percent Cost-MS. C.P. Hr.	M.H.C.P. of Unit.	Cost Per M.H. C.P. Hr.	Percent Cost Per M.H.C.P. Hr.	Life of Mantles, &c. hrs.	REFERENCES.
Tungsten.	60w	10¢/KWH	$ .006	$ .0011	$ .0071	(1) 36.6	$ .000194	100	(1) 39.36	$ .00018	100	1000	(1) Lansingh & Cravath
3.1w Carbon.	50w	"	.005	.00033	.00533	(2) 13.2	.000404	208	(2) 11.68	.000451	254	(1) 500	(1) U of I. Test Lab. (2) Lansingh & Cravath.
3.5w. Carbon.	55w	"	.0055	.0004	.00554	(2) 13.2	.00042	216	(2) 11.68	.000475	264	(1) 600	(1) U of I. Test Lab. (2) Lansingh & Cravath
Nernst	396w	"	.0396	.00089	.0405	191.5	.000115	59.3	344.0	.000118	65.5	See Nernst Lamp.	Electrical World. Oct. 1908.
Inv. Gas	(1) 3 cu. ft	$1.00/1000 ft	.003	.001	.004	(1) 54.0	.000074	38.1	(1) 70.6	.0000567	31.5	500	Lansingh & Cravath.
Upr't Gas	(1) 3.7 cu. ft	"	.0037	.001	.0047	(1) 63.6	.000075	38.7	(1) 51.27	.0000917	51.0	500	Practical Illumination
Open Gas	5.0 Cu. ft	"	.005	---	.0050	21.0	.000238	122.5	20.0	.00025	139.0	---	Prac. Illum.
Acetylene	.5 cu. ft.	7.78/1000 ft	.0038	---	.0038	12.7	.0003	155.0	11.6	.000328	182.0	---	(1) Union Carbide Co. Prac. Illum.
Gasoline Inv.	.2 Pint	16¢/Gal.	.004	.00085	.00485	(1) 47.0	.000103	53.2	(1) 53.9	.0009	46.4	(1) 330	U. of I. Test Lab.
Oil Mantle	.143 pt	"	.0029	.00075	.00365	19.0	.000192	99.0	17.0	.000215	119.0	500 Man. 1000 Chimney.	U of I Test Lab.
Oil Wick	.068 pt	"	.0014	.0003	.0017	5.7	.0003	155.0	4.9	.000347	193.0	30¢ per 1000 Hrs.	U. of I. Test Lab.

In the above table calculations are based upon the number of hours life of mantles & as given. In the case of the Nernst lamp, the life of the various parts is taken from the table given under electric lighting, taking three glower lamp for 60 cycles, A.C. For gas lamps, mantles are taken with a life of 500 hours and the life of the chimney is 1000 hours making a total renewal cost of .75 cents for 1000 hours. To this must be added the inspection-maintenance charge of the gas company of $ 2.40 per year, one year's burning is approximately 1000 hours. This latter assumption is made in the Welsbach bulliten s and is no doubt fair to the gas. For gasoline lighting, the mantle life of a mantle costing 10 cents is 330 hours. For maintenance of the plant per 1000 hours a charge of 50 cents is made. This is the amount quoted by the Incandescent Light and Stove Company. For the oil mantle lamp a mantle life is taken as 500 hours and the life of the chimney is taken as 1000 hours. The total maintenance cost of the wick lamp is taken as 30 cents per 1000 hours, or 30 cents per year.

UNIVERSITY OF ILLINOIS-URBANA
3 0112 086857494